

Photogrammetric Close-Range CAD System

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Abstract

The design of a direct interface between a close-range photogrammetrical system and a 3D CAD/CAM/CAE system is described.

The combination has facilities for creating 3D object models interactively, on the CAD screen, from stereo comparator or analytic plotter measurements. The models include simple line, polylines and arcs as well as cylinders, planes and cones. The CAD system is then used for intersecting the surfaces and planes, thus creating a powerful tool e.g. for creating as-built 3D pipe drawings.

The entire system is built in a personal computer environment.

Introduction

This paper describes a Non-Topographical photogrammetrical data reduction system put together by combining a photogrammetrical system with a CAD system. An investigation is made regarding the feasibility and philosophy behind such a system. Three different CAD systems is tested for feasibility and usefulness together with one photogrammetrical system.

The test is performed in a personal computer environment. There are two reasons for this. The first is that cost effectiveness is important for non-topographical applications, and that the photogrammetrical part of the system was available on such a machine.

2 The significance of a drawing

Photogrammetry is a tool for the measurement of geometrical information. It is ideally suited for assembling maps and drawings, two products that can be seen as graphical measuring protocols. Every detail on a photogrammetrical drawing is actually measured by a manual setting in a stereo model.

Using a CAD system for drawing production, on the other hand, is something quite different. The draughtsman creates a drawing according to a set of geometrical rules, putting together simple shapes like cubes, cylinders and cones. The drawing is a description on a high level, of an object that is idealized in the mind of the draughtsman.

Where the CAD drawing is used for the construction of an actual, real world object, the photogrammetrical drawing is a documentation of the object as built.

The difference between the construction and the as-built drawing, consists of two components. One component is the inevitable error inherent in the measuring process. The other component is the actual deviation between design and object.

When a drawing is produced with photogrammetry, correctness and completeness are two fundamental aspects of quality. When the same object is documented using CAD system facilities to aid the operator in creating the drawing, quite a different product may be created.

With CAD possibilities, the operator can simplify his work by taking shortcuts. A number of windows on a facade can be

drawn as copies of one window. A symmetrical object can be measured as one half only, which can be mirrored to create the impression that the entire object has actually been measured.

The operator can put a lot of effort in creating window number one, in the knowledge that all other windows can quickly be copied from the first.

What if the windows are slightly different? Or the object only approximately symmetrical? Is the CAD-enhanced drawing better? Or the traditional?

These differences must be known by the client. He who is the user, must know in advance if the drawing will be a true as-built or if it is some kind of interpretation of the original design of the object.

We must not exclude the use of any of the two products. The only concern is that we, as photogrammetrists, must be conscious of the possible differences between the two kinds of drawings.

3 Aim

Having said the above, the actual project will be described.

The aim is, in essence, to be able to use existing CAD systems to enhance the graphical editing possibilities of a photogrammetrical drawing system.

For one thing, the availability of CAD in PC environments has gradually grown to a state today, where the functionality and capacity has exceeded all expectations. PC CAD systems are mostly versatile, functional, powerful, capable and well proven. They are also a good buy, the fierce competition means much capacity for little money.

The same is not true for photogrammetrical systems, at least not for the majority of them. Small market segments means that good products also are expensive.

This leads to the simple idea to combine the two worlds. Let us build an interface between photogrammetry and CAD.

The CAD community has since long offered mapping application packages to their systems, with varying (commercial) success. The application we have in mind is not mapping, but Non-Topographical applications in general, both in 2D and 3D.

Photogrammetrical data reduction and drawing systems have recently been made available in greater numbers on PC computers. The package used in this test is the IDAC 70 system, distributed by Hasselblad Engineering AB, Sweden.

Other, similar systems may have been used, but for the success of the project, it was important that the source code was available for modification.

IDAC 70 also has the advantage that it is a system, designed for Non-Topographical applications, with a number of facilities specifically designed for such work.

The actual interface can basically be devised in two ways, off-line and interactive. Intermediate level interfaces can also be used, with a varying amount of interactiveness.

4.1 Off-line interface

The off-line interface consists of a file transfer facility from the photogrammetric to the CAD system. The minimum amount to transfer is the coordinates for the lines, polylines and other graphical entities drawn. Preferrably, all drawing information should be transferred as well, in order for the CAD system to draw the finished design automatically, without further human interaction.

Most CAD systems have transfer file formats, simple enough for interfacing. The internal drawing data base of most CAD systems is too complex to write directly into.

If the photogrammetric system is supplied with graphical on-line drawing, this simple system may be very useful. Through on-line check and correction possibilities, the drawing entering the CAD system is already checked for correctness and completeness.

More complex editing of the drawing can then be performed in the CAD system, which also is used to produce the final document on paper or on other media.

This solution is often very efficient. Each part of the combination is used for what it is designed for. During measuring, the full CAD editing possibilities are seldom needed, and during editing, the actual measuring data are kept as a reference file, not to be modified.

4.2 Interactive interface

The interactive interface is considerably more complex to implement. It consists of three main parts: the first being a module for the computation of the photogrammetric model out of the stereo pair. This part is often available and used as it is, its main function is to deliver all parameters for the transformation of photogrammetrical measurements into absolute coordinate triples.

That information is typically stored in a file, accessible using the model id as file name or key quantity.

The second and third parts of the interface are modules, internal to the CAD system. Most CAD systems are programmable through a special language, typically named User Command Language or User Program Language, to mention a few examples. The modules are either programmed entirely in that language or in ordinary languages like C or Pascal. In the latter case, the modules are loaded on commands from the CAD program language.

The function of the second module is simply to identify the current photogrammetric model for the CAD system, or more specifically, to load the current model parameter data into a structure, internal to the CAD system.

The third module, finally, are used for the actual transfer of data from the photo pair into the CAD data base, all transformations, corrections etc included. The result of a sample operation at the plotter will typically be a point in the CAD system workspace.

That point may be used in many ways in the CAD system. Normal operations are commands like place-line, place-line-string, place-arc etc. In some implementations, the third module can in fact be a full set of modules, each inserting a different entity type in the CAD data base.

It is important to note, that the work is controlled by the CAD system all the time. The only exception is when the CAD system is waiting for data from the photogrammetrical plotter.

Examples

The first example is an architectural drawing of all four walls of a building, subject to restoration. It is a Functionalistic house, all windows on the facades appear to be identical in size and looks. See figure 1.

It may not be apparent from figure 1 in that scale, but it turned out, that the windows, although looking very similar, varied both in size and position. The actual position and size of all windows were of great importance in the planning of the restoration. In this case, using a "draw and copy"-method would completely spoil the relation to the client.

Figure 1 were produced using IDA2D, the drawing package of the IDAC 70 system, at the Flygfältsbyrå AB, a Swedish construction consultant agency. It was transferred off-line to Auto-CAD for plotting. Most important however, was that the client used the files directly, in his own Auto-CAD system, thereby simplifying his own design work considerably.

Another example can be seen in figure 2. Here the object is a die cast mold, of which copies must be made. The aim was here to produce a 3D design, possibly generalized from the original mold. The mold is mainly a rotational surface, generated by a profile, which is the intersection between the surface and a plane through the axis of the mold.

To complicate the design, part of the mold is a regular octagonal instead of a cylinder.

In this example, Non-Topographical photogrammetry and CAD were combined for the production of the final mold design. Photogrammetry is used for measuring the generating profile and CAD is used to produce the surface by rotating the profile around its axis.

Photogrammetry was also needed to measure the details around the octagonal-shaped part of the mold.

The surface was then generated by first creating a dense wire-frame model and then by producing a surface model, a function provided by the CAD system. The surface model can be seen in figure 3.

More important, the CAD system had in this case facilities for producing control files for a numerically controlled cutter. By this process, the mold can not only be measured as it is, but also slight deviations from the cylindrical form may be eliminated by the generation of the surface by a combination of empirical and geometrical methods.

This project was also carried out in collaboration with Flygfältsbyrå AB. The IDAC 70 system was in this case used with an interactive interface from the CAD system, Personal Designer, a PC-based CAD system from Computervision.

An off-line CAD interface for IDAC 70 is also available for Microstation, an Intergraph-compatible PC-based CAD software distributed by Intergraph.

In all cases, the CAD interfaces have been produced by Hasselblad Engineering AB, Sweden.

6 Conclusions

The aim, to enhance the graphical capabilities of a photogrammetrical data reduction system has been reached.

The added functions and design capabilities add new possibilities for producing both as-built and design drawings. This will make it possible to use photogrammetry for solving measuring and documentation tasks.

Furthermore, the capacity of designing construction drawings and the possibility to use these for NC construction is added to the field of photogrammetry.

These two aspects of a drawing must be recognised and the difference made clear for all parts acting on the photogrammetry market.

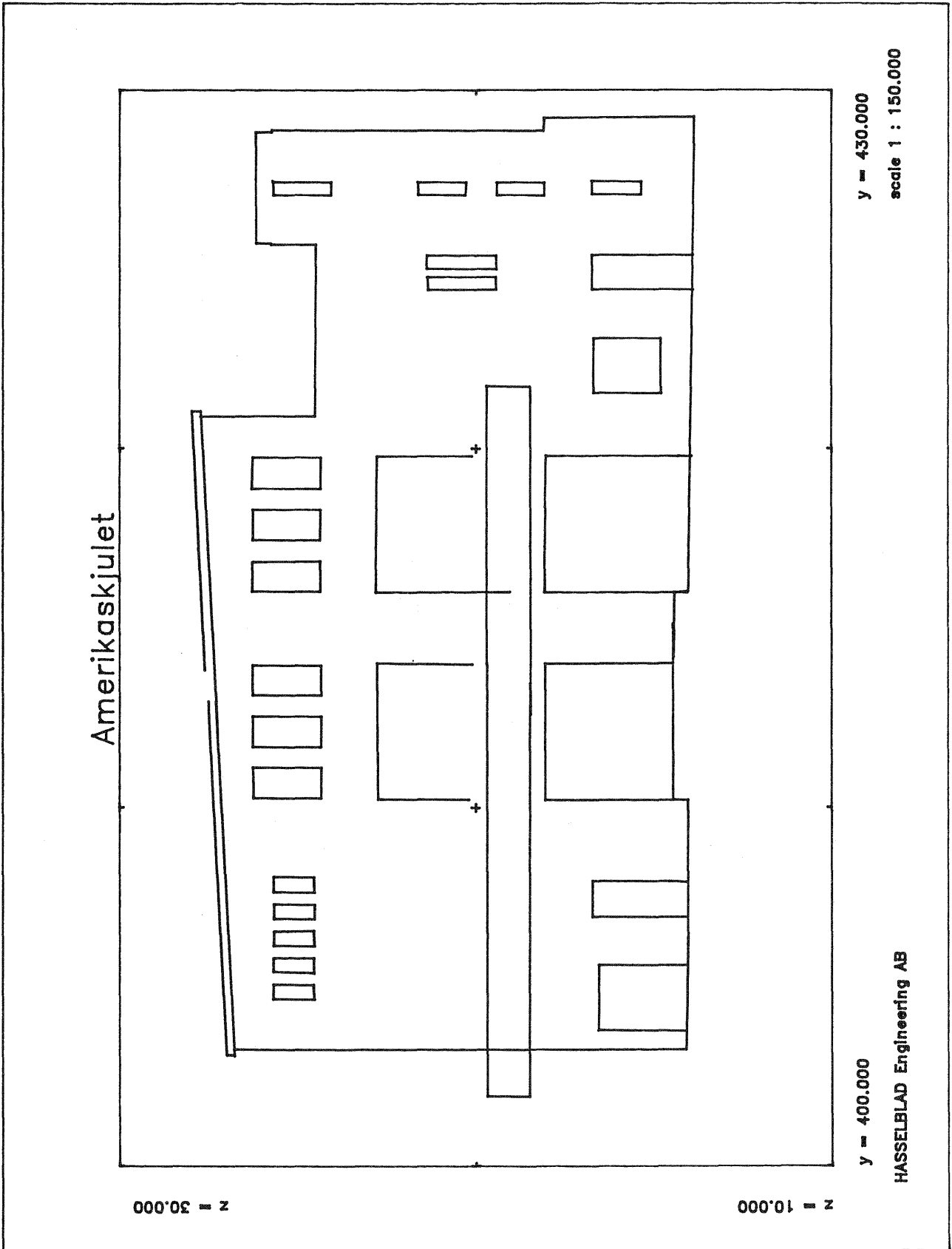


Figure 1
 As-built drawing
 Courtesy Hasselblad Engineering AB

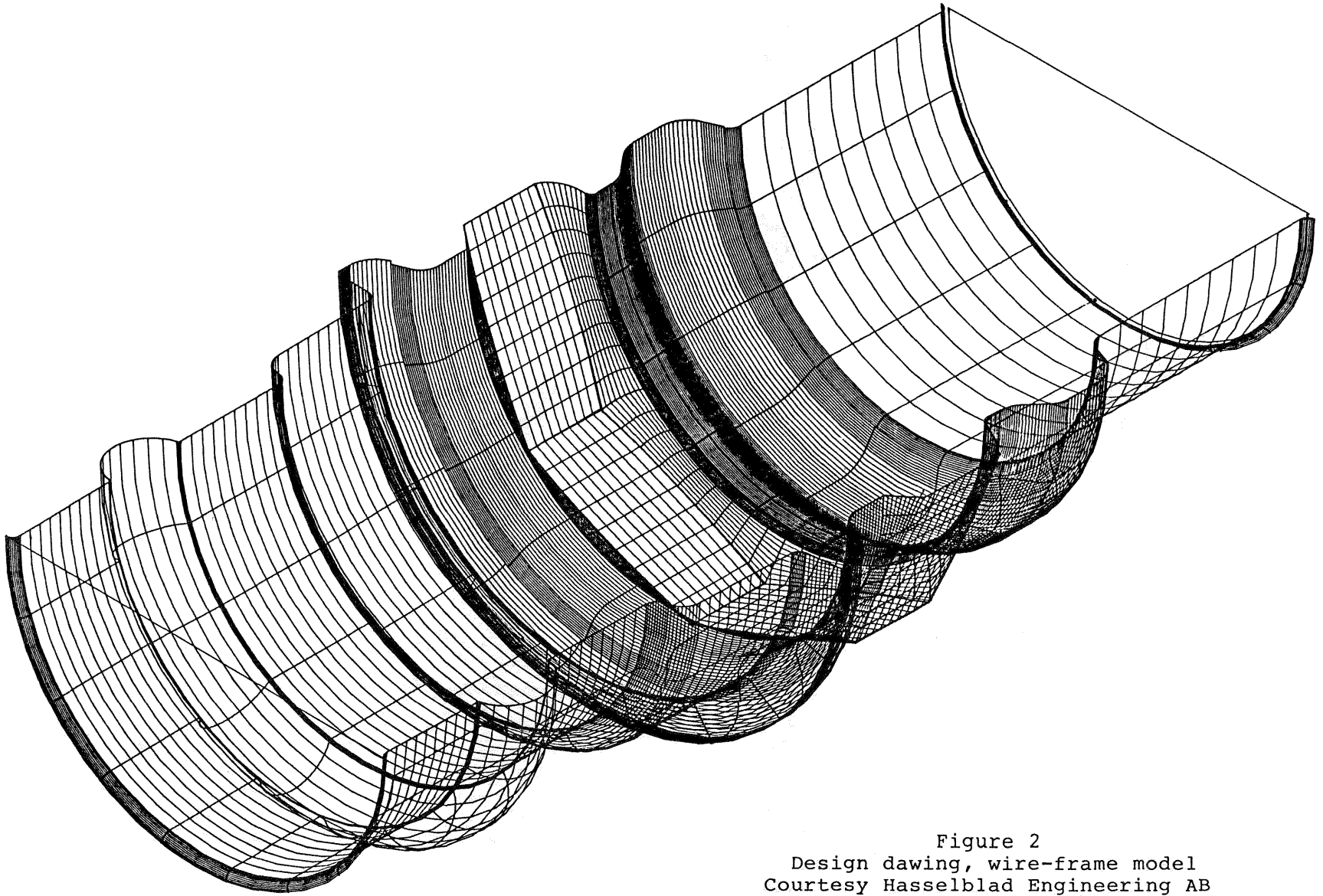


Figure 2
Design drawing, wire-frame model
Courtesy Hasselblad Engineering AB
Courtesy Flygfältsbyrån AB and Computervision

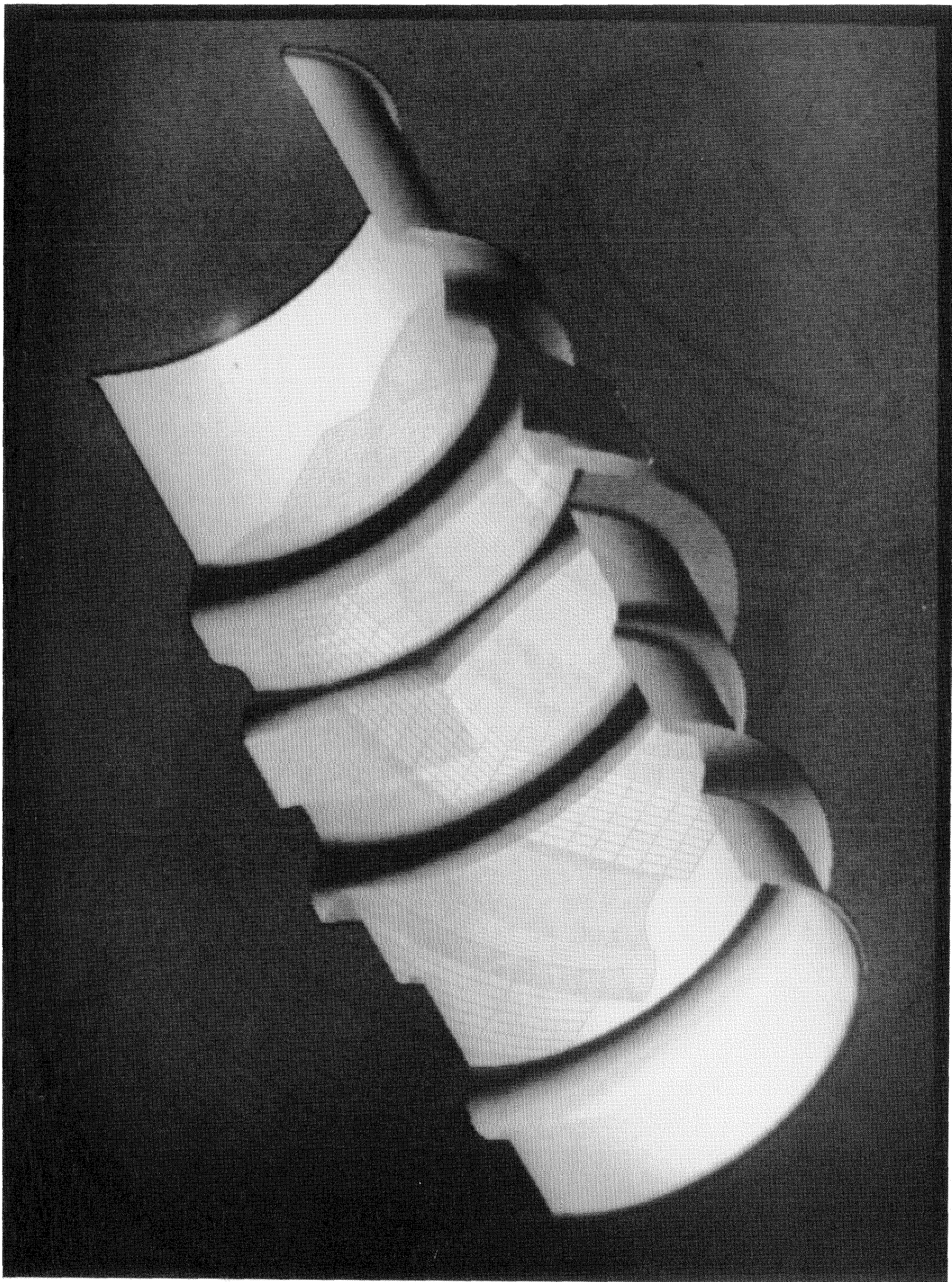


Figure 3
Design drawing, surface model
Courtesy Hasselblad Engineering AB
Courtesy Flygfältsbyrån AB and Computervision